THE EFFECT OF EM-4 (EFFECTIVE MICROORGANISMS) IN FOOD WASTE ON METHANE GAS PRODUCTION (CH_4)

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ABSTRACT

The purpose of this study is to determine the effect of adding EM-4 (effective microorganism) to temperature, pH, and methane gas production in the digester/reactor. The method used in this research is the descriptive quantitative experimental. The test is carried out using a simple digester/reactor design to measure temperature, pH, and the production of methane gas by food waste. The measurement results show that the more EM-4 added to the reactor, the faster the gas formation and the longer the gas production process, so that more gas is produced. However, this process does not change the process or stages of biogas formation. There is no change in pH or temperature values. To determine whether the methane gas occurs in the product, a flame test is carried out. Treatment A1 produces a blue and yellow flame, treatment A2 does not produce any flame, treatment B1 and treatment B2 produce a blue flame. The presence of a flame indicates that there is a methane gas content in the gas produced, estimated at 45%. The color of the flame is affected by the level of CO2. Combustion of fuel without CO2 will produce a blue flame, while combustion that produces a reddish yellow flame is caused by the presence of CO2. The absence of flame in treatment A2 indicates that the product gas in the treatment is sparse.

Keywords: *Effective Microorganism; EM-4; Food Waste Management; Household Waste Management*

INTRODUCTION

Global temperature increases because of greenhouse gases (GRK) may lead to climate changes across the world. The adverse impacts by virtue of GRK are ever-increasing, one of which is increased levels of methane (CH4) gas produced by waste. Additionally, the population growth rate also influences the increased GRK.

Waste comes from population activities, especially those living in rural areas. Increased production of waste, notably food waste, is a potential cause of increased methane gas production. The 2017 study by the Economist Intelligent Unit (EIU) demonstrated that Indonesia is the second-largest food waste producer at the global level. The number of food waste in Indonesia is 1.3 gigatons/year or one-third of the number of food materials produced (FAO, 2011). Meanwhile, in the European continent, according to the report of the European Commission (2011), the number of food waste produced is approximately 88 million tons/year, at the mean waste production/individual is 180 kg/year. Accordingly, one-fourth of food bought at the household level is allegedly thrown as garbage. The household sector contributes to 42% of the total food waste. The habit of leaving leftovers is the factor greatly affecting the increase in the number of food waste. In addition, poor planning and inappropriate storing technique are two other factors breeding a large amount of food thrown.

Food waste is an organic waste we may find many in temporary dumps and landfills. If poorly managed, they will bring about diseases and environmental damages due to the methane gas they produce. A preventive action to reduce methane gas emission is by researching the causes, allowing us to find the best strategy. One of the avenues is by optimizing the role of microorganisms, i.e., by adding activators, e.g., EM-4 (effective microorganisms). EM-4 microorganisms used are inoculants from the EM-4 type. The inoculants are composed of 90% of Lactobacillus Sp., which produces lactic acid, accelerating decomposition of organic matters, inter alia, lignin and cellulose.

This research focuses on studying the effects of EM-4 administration on pH and temperature during the process of producing methane gas by food waste. Besides, it brings into focus the analysis of the effect of EM-4 administration on methane gas production.

METHOD

This is descriptive-qualitative experimental research. The experiment is carried out by delivering two treatments twice.

A^{1-2} : digester containing food wastes + water (1 liter of water = 3 kg of food waste) + 10 mL of EM-4 (1:3:1)

B^{1-2} : digester containing food wastes + water (1 liter of water = 3 kg of food waste) + 20 mL of EM-4 (1:3:1)

The fermentation process takes place over the course of 42 days. pH is tested using a pH meter, while the temperature is gauged using a psychrometer. The gas pressure produced is measured using a manometer (pressure gauge). Measurement is daily executed during the fermentation period.

RESULT AND DISCUSSION

The process of fermentation to bring on biogas from food wastes is performed within an artificial reactor. The reaction happening inside is an anaerobic or without-air reaction. Food waste used is coarsely chopped to allow a perfect chemical fermentation process. The wider the touch area surface, the faster the biogas formation reaction. Microbes act as effective microorganisms, i.e., mixed cultures of fermented (yeasting) and synthetic (combination) microorganisms which react synergically to ferment organic matters. Through the process of fermentation, organic matters are altered into glucose, alcohol, and amino acid (Subadiyasa, 2007).

The fermentation process in food waste happens in three stages. The first stage is hydrolysis, where insoluble materials, such as cellulose, polysaccharides, and fat, are transformed into soluble ones, e.g., glucose. This stage is called hydrolysis as there occurs dissolution of the compound with water as the hydrolysate. Microbes contribute to the decomposition of the long chains of carbohydrates, proteins, and fat into shorter ones, creating a pH range close to a neutral condition, i.e., 6. The reaction for breaking the bonds of polysaccharides into monosaccharides can be defined as follows:

$$(C_6H_{10}O_5)_n + n\ H_2O \rightarrow n\ C_6H_{12}O_6$$

Cellulose
Glucose

The second stage is when acid bacteria engender acetic acid in an anaerobic situation. The stage occurs in the digester at 25°C. This stage takes place on the third day of the fermentation process. The bacteria will generate acid serving to transform short compounds brought on from the hydrolysis process into simple organic acids, e.g., acetic acid, H_2, and CO_2. Accordingly, the bacteria are also called acidogens. The bacteria are anaerobic and hence can grow in an acid environment. To generate acetic acid, it needs 16 days as most organic wastes used are fruit-based. The reaction in this stage is delineated as follows:

$$n\ C_6H_{12}O_6 \rightarrow 2n\ (C_2H_5OH) + 2n\ CO_2 + \text{Heat}$$

Glucose
Ethanol Carbon dioxide

The reaction equation demonstrates the formation of ethanol and carbon dioxides at a pH of 5-6, whereas heat produced is observable using the measuring tool directly installed on the reactor, in which the temperature exhibited 25-30°C. Ethanol and carbon dioxides are altered into acetic acid and methane gas. The presence of acetic acid is identified by gauging the pH which indicates a value of 4-5, wherein the pH value for acetic acid is ± 5 (Underwood, 1989). The process initiates the process of methane gas production, the reaction of which is as follows:

$$2n\ (C_2H_5OH)_{(aq)} + n\ CO_{2(g)} \rightarrow 2n\ (CH_3COOH)_{(aq)} + n\ CH_{4(g)}$$

Ethanol Carbon dioxide Acetic acid Methane

The third stage constitutes the methanogenesis stage, where the bacteria embark upon the methane gas formation slowly in an anaerobic condition. The process takes ± 14 days at maximum until microorganisms die slowly at 33-36°C. This process results in methane gas, carbon dioxides, and a small amount of hydrogen gas. The reaction in this stage is as follows:

$$2n\ (CH_3COOH) \rightarrow 2n\ CH_4 + 2n\ CO_2$$

Acetic acid
Methane
Carbon dioxide

Biogas yielded will evaporate slowly through a calve provided at the reactor lid and lead to the placeholder, i.e., a balloon, and is tested for the existence of methane gas in it.

A. The Effect of EM-4 Administration on pH

Table 1. Ph After EM-4 Administration of 10 mL and 20 mL

Day	EM-4 Administration of 10 mL	EM-4 Administration of 20 mL
1	6.80	6.80
2	6.79	6.77
3	6.61	6.55

4	6.52	6.34
5	6.42	6.25
6	6.34	6.12
7	6.20	5.88
8	6.03	5.73
9	5.93	5.54
10	5.84	5.46
11	5.71	5.32
12	5.64	5.25
13	5.56	5.20
14	5.42	5.11
15	5.36	5.05
16	5.22	4.89
17	5.01	4.71
18	4.83	4.65
19	4.65	4.60
20	4.56	4.56
21	4.42	4.50
22	4.36	4.48
23	4.29	4.44
24	4.22	4.38
25	4.31	4.32
26	4.38	4.26
27	4.51	4.18
28	4.67	4.22
29	4.72	4.31
30	4.91	4.40
31	5.21	4.53
32	5.33	4.62
33	5.40	4.75
34	5.57	4.84
35	5.64	4.89
36	5.76	5.04
37	6.02	5.11
38	6.15	5.26
39	6.21	5.31
40	6.43	5.42
41	6.52	5.54
42	6.62	5.66

Table 1 manifests the effect of EM-4 administration on pH during the process of biogas production. As pointed out, there is no significant difference between EM-4 administration of 10 mL and 20 mL, the clear curve of which is presented in Figure 1.

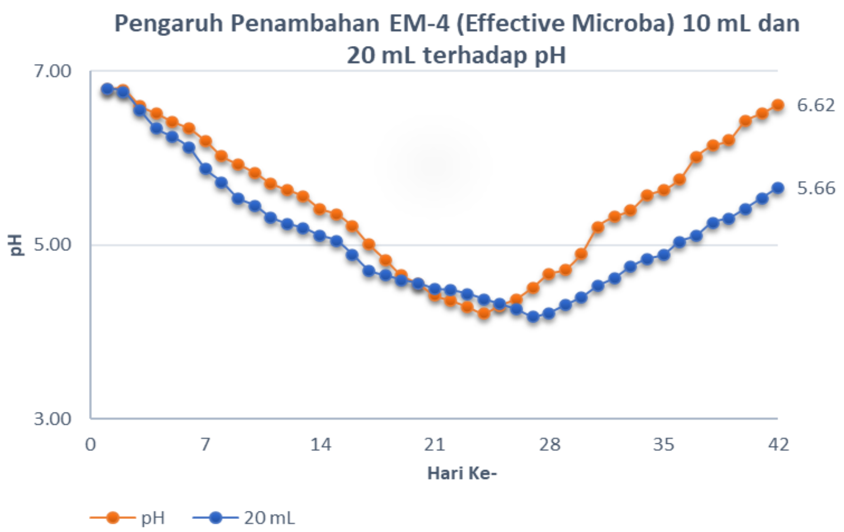

Figure 1. The Effect of EM-4 Administration of 10 mL and 20 mL on pH

The formation of biogas is consistent with the microbial growth period, namely on the peak curve, and turns down slowly aligned with the microbial living level. And yet, the formation of acetic acid in treatment 2 (EM-4 administration of 20 mL) occurs faster, which is on day 14. The pH is 5.11 at 33°C. On the other hand, the formation of acetic acid in treatment 1 (EM-4 administration of 10 mL) takes place on day 16. The pH is 5.22 at 33°C. This breeds a difference in biogas production between each reactor. That being so, EM-4 administration has no significant effect on pH during the process of biogas production but has an effect on the time when the acetic acid formation initiates, and therefore, affects the duration of biogas production and the amount of biogas brought about.

B. The Effect of EM-4 Administration on Temperature

Table 2. Temperatures After EM-4 Administration of 10 mL and 20 mL

Day	EM-4 Administration of 10 mL	EM-4 Administration of 20 mL
1	24	24
2	24	25
3	25	26
4	26	27
5	26	27
6	27	28
7	28	29
8	29	30
9	30	30
10	30	31
11	30	31
12	31	32
13	31	32
14	32	33

15	33	33
16	33	34
17	33	34
18	34	35
19	34	35
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28	34	34
29	33	34
30	32	33
31	31	33
32	30	32
33	29	32
34	28	31
35	27	31
36	26	30
37	26	29
38	25	28
39	25	27
40	25	26
41	25	26
42	25	25

Table 2 demonstrates the effects of EM-4 administration on temperature during the process of biogas production. As exhibited in Table 4, there is no significant difference in the effects between EM-4 administration of 10 mL and 20 mL. It is clearly delineated in Figure 2.

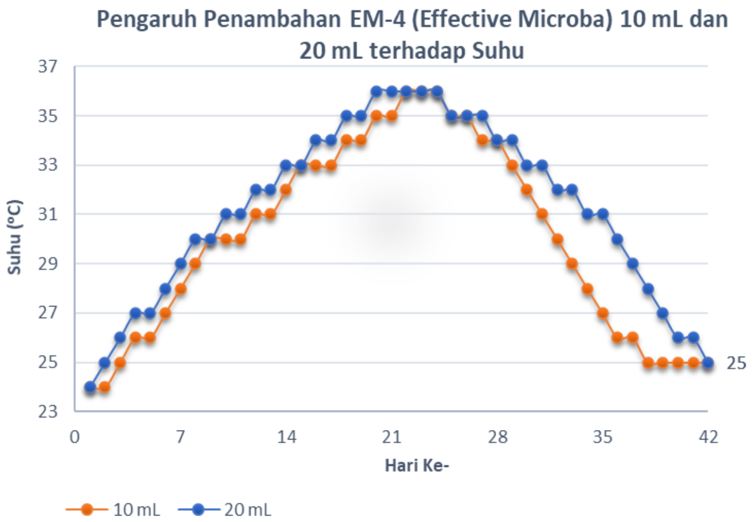

Figure 2. The Effect of EM-4 Administration of 10 mL and 20 mL on Temperature

We can analyze clearly from Table 2 and Figure 2, that there is no significant difference in the temperature of reactor administered with EM-4 of 10 mL and that of reactor administered with EM-4 of 20 mL. However, the treatments take different periods to achieve the temperature of 30°C. Treatment 1 (EM-4 administration of 10 mL takes nine days, whereas treatment 2 (EM-4 administration of 20 mL) takes only eight days to achieve a temperature of 30°C. Within the period, the gas produced from the reactor is CO_2 gas. When the temperature of 30°C is reached, methane gas commences being produced, whereas CO_2 gas embarks upon decreasing.

C. The Effect of EM-4 Administration on Methane Gas Production

1. Biogas Mass

Table 3 indicates biogas produced during 42-day fermentation.

Table 3. Data of Gas Mass Gauging

Accumulated Mass (g)					
EM-4 Administration of 10 mL			EM-4 Administration of 20 mL		
A^1	A^2	Mean	B^1	B^2	Mean
7	6	6.5	8	9	8.5

Gas stored in the container balloon is weighed using a digital scale. Treatment 1 brings about biogas of 6.5 g, while treatment 2 brings on heavier biogas at a mass of 8.5 g. Additionally, another product engendered in the reactor is liquid compost. Composting happens in an aerobic or anaerobic manner by administering EM-4. In this process, microorganisms will work effectively in an appropriate condition (Yuwono, 2016).

Microorganisms contained by EM-4 have a good impact on the quality of fertilizer made of organic materials, e.g., food waste. The time entailed by bacteria in waste degradation highly influences nutrient availability in organic fertilizer. After 42-day fermentation, decomposed food wastes will transform into thick liquid-like, slightly textured materials which have a pH of 5-6.

EM-4 administration affects the amount of biogas produced. The more the amount of EM-4 administered to the staple materials, namely food waste, the more the biogas produced. It occurs as EM-4 functions to accelerate the fermentation process of staple materials used to generate biogas. Managing food wastes as renewable energy is one of the efforts to minimize waste impacts on global warming. Methane gas resulted from food waste and left in the air will accumulate in Earth's atmosphere and remain within ten years, whereas CO_2 gas will stay for 5-200 years (Kendra, 1997). With good waste management, the rate of methane gas formation can be minimized and thereby having a slight influence on environmental damage.

2. Flame Test

A flame test to biogas produced through anaerobic fermentation aims to examine if methane gas is yielded within the biogas container balloon. Biogas containing methane gas will burn when approached by a fire source. The result of the flame test is manifested in Table 4.

Table 4. The Result of Flame Test to Biogas Produced

Treatment	Flaming	Not Flaming
A^1	√	
A^2		√
B^1	√	
B^2	√	

As pointed out in Table 4, of four reactors used, reactors A^1, B^1, and B^2 produce biogas which burns when approaching a fire source, whereas reactor A^2 does not result in any flame. This attests to the existence of methane gas in reactors A^1, B^1, and B^2. Reactors B^1 and B^2 yield a flue flame, showcasing no CO_2 in them. On the other hand, reactor A^1 breeds blue and yellow flames, showing off the presence of CO_2. Biogas brought about by reactor A^2 does not flame because not having methane gas.

The Gorontalo Governor Regulation Number 20/2019 concerning Policies and Strategies for Household and Similar-household Waste Management Article 3 states that reducing household or similar-household wastes can be carried out by:

a. Restricting the generation of household or similar-household waste.
b. Recycling household or similar-household waste.
c. Reusing household or similar-household waste.

The three actions can be manifested by affording skill training or assistance to the community. One of the training which can be conducted is as regards the technique of making a simple biogas reactor using food wastes as staple materials with EM-4 administration. Also in the training, the community can be conferred materials of using the resultant gas and processing biogas wastes into compost.

CONCLUSION

EM-4 administration in the making of biogas from food wastes accelerates gas formation. The longer the process of gas production, the more the resultant gas. And yet, this process alters neither pH nor temperature of biogas production. The flame test proves the existence of methane gas in the resultant biogas. Treatment B breeds blue flames in both reactors, whereas treatment A brings about yellow flames in one reactor but no flame in another. The blue flames exhibit the non-existence of CO_2, the reddish-yellow flames indicate the existence of CO_2, whereas no flame is indicative of a small amount of methane gas contained in the resultant biogas.

REFERENCE

Alfan, M., 2017, Dampak Tempat Pembuangan Akhir (TPA) Sampah Kebon Kongok terhadap Gangguan Kesehatan Masyarakat Desa Suka Makmur Kecamatan Gerung Kabupaten Lombok Barat, **Undergraduate Thesis**, Universitas Islam Negeri Mataram

Dewilda, Y., Aziz, R., and Fauzi, M., 2019, Kajian Potensi Daur Ulang Sampah Makanan Restoran di Kota Padang, Jurnal Serambi Engineering, Vol. **4 (2)**

Ghosh, R. and Eriksson, M., 2018, Food Waste Due to Retail Power in Supply Chains: Evidence from Sweden. Global Food Security, Vol. **20**:1-8

Giordano, C., Alboni, F., Cicatiello, C., and Falasconi, L., 2019, Do Discounted Food Products End Up in the Bin? An Investigation into the Link Between Deal-Prone Shopping Behaviour and Quantities of Household Food Waste, International Journal of Consumer Studies, Vol. **43 (2)**:199–209

Irawan, D. and Suwanto, E., 2016, Pengaruh EM-4 (Effective Microorganism) terhadap Produksi Biogas Menggunakan Bahan Baku Kotoran Sapi, TURBO, Vol. **5 (1)**

Marliani, N., 2014, Pemanfaatan Limbah Rumah Tangga (Sampah Anorganik) sebagai Bentuk Implementasi dari Pendidikan Lingkungan Hidup, Formatif: Jurnal Ilmiah Pendidikan MIPA, Vol. **4 (2)**

Mujdalipah, S., Dohong, S., Suryani, A., and Fitria, A., 2014, Pengaruh Waktu Fermentasi terhadap Produksi Biogas Menggunakan Digester Dua Tahap pada Berbagai Konsentrasi Palm Oil-Mill Effluent dan Lumpur Aktif, Agritech, Vol. **34 (1)**:56-64

Mulyana, I. J., Gunawan, I., and Tamara, I., 2019, Studi Eksploratif Manajemen Sampah Makanan pada Jaringan Toko Produk Pangan di Indonesia, Industria:

Jurnal Teknologi dan Manajemen Agroindustri, Vol. **8 (2)**

Omar, H. and Rohani, S., 2015, Treatment of Landfill Waste, Leachate, and Landfill Gas: A Review, Front. Chem. Sci. Eng, Vol. **9 (1)**:15–32

Pratiwi, Y., Purnawan, and Warisaura, A. D., 2016, Kajian Pengaruh Pelumatan dan Penambahan Aktivator terhadap Produksi Biogas dari Sampah Sisa Makanan Restoran, Prosiding Seminar Nasional Teknik Kimia "Kejuangan" Pengembangan Teknologi Kimia untuk Pengolahan Sumber Daya Alam Indonesia, Yogyakarta: March 17th, 2016:1-7

Rahma, R. A. A., 2015, Pengaruh Paparan Gas Metana (CH4), Karbon Dioksida (CO2), dan Hidrogen Sulfida (H2S) terhadap Keluhan Gangguan Pernapasan Pemulung di Tempat Pembuangan Akhir (TPA) Sampah Klotok Kota Kediri, **Thesis**, Universitas Sebelas Maret, Surakarta

Septeyadi, M. D., 2019. Emisi Metana (CH_4) Sedimentasi Keramba Situ Gintung dengan Penambahan Subsrat Kompetititf dan Substrat Non-Kompetitif, **Undergraduate Thesis**, Universias Islam Negeri Syarif Hidayatullah, Jakarta

Wang, J., Chen, Z., Yang, L., and Xi, S., 2015, Study on Trends and Performance of Landfill Research from 1999 to 2013 by Using Bibliometric Analysis. Environ. Prog. Sustain. Energy, Vol. **34 (5)**:1349–1355

Wulandari, Winda and Asih, Anna Maria Sri, 2020, Perilaku Rumah Tangga terhadap Food Waste di Indonesia: Studi Literatur. In: Seminar Nasional Teknik Industri (SENTI) UGM, October 5th, 2020, Yogyakarta

Wulansari, D., Ekayani, M., and Karlinasari, L., 2019, Kajian Timbulan Sampah Makanan Warung Makan, Ecotrophic, Vol. **13 (2)**